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PROVISIONAL APPLICATION FOR PATENT COVER SHEET

This is a request for filing a PROVISIONAL APPLICATION FOR PATENT under 37 CFR 1.53(c).

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☐ *Additional inventors are being named on the ______ separately numbered sheets attached hereto*

TITLE OF THE INVENTION (500 characters max)

METHOD AND APPARATUS FOR OBTAINING CENTER OF K-SPACE DATA

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ENCLOSED APPLICATION PARTS *(check all that apply)*

☒ Specification *Number of Pages* 4
☒ Drawing(s) *Number of Sheets* 2
☐ Application Data Sheet. See 37 CFR 1.76
☐ CD(s), Number
☐ Other (specify)

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Respectfully submitted,

SIGNATURE Tom Lund

Date 23-Sep-2003

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USE ONLY FOR FILING A PROVISIONAL APPLICATION FOR PATENT

METHOD AND APPARATUS FOR OBTAINING CENTER OF K-SPACE DATA

By: Thomas Cull, Laura Gaul, and Sara Oberrecht

BACKGROUND

The present invention relates to the field of medical imaging and has particular applicability to magnetic resonance imaging. More specifically, the invention relates to a method and apparatus for obtaining data from the center of k-space, particularly during magnetic resonance angiography acquisitions.

For real-time MR angiography acquisitions, the results are usually obtained by acquiring k-space data in an order based on the proximity of the data points to the center of k-space.

Previous methods typically require some form of data sorting based on the distance from the center of k-space. Some of these sorting algorithms scale in operation as the number of points to the second power, which results in slow computation for typical acquisition slice and phase k-space data sizes can be on the order of 10,000 points or more.

Further, some previous methods tend to have image blurring along an encoding axis, which can lead to incorrect image evaluation.

SUMMARY

Those skilled in the art will, upon reading and understanding the appended description, appreciate that aspects of the present invention address the above and other matters.

In accordance with one embodiment of the invention, an apparatus is provided to acquire k-space data timed such that low frequency components (e.g. center of k-space) are acquired during a peak of signal enhancement.

In accordance with another embodiment of the invention components from the center of k-space are acquired in relation to a peak of signal enhancement resulting from a contrast agent.

In accordance with another embodiment of the invention, the peak of signal enhancement results from a bolus contrast agent.

One advantage of an embodiment of the invention is that a reduction in sorting k-space is facilitated.

Another advantage of an embodiment of the invention is that it facilitates a reduction in sequence computation.

Another advantage of an embodiment of the invention is that it facilitates a reduction in compilation time.

Another advantage of an embodiment of the invention is that reconstruction of slice direction data can be performed upon filling all slice data points for a given phase column.

Another advantage of an embodiment of the invention is that a reduction in the latency between scan completion and image reconstruction is facilitated.

Still further advantages of the present invention will become apparent to those of ordinary skill in the art upon a reading and understanding of the following description of the preferred embodiments.

DRAWINGS

The invention may take form in various components and arrangements of components, and in various steps and arrangements of steps. The drawings are only for purposes of illustrating a preferred embodiment and are not to be construed as limiting the invention.

Figure 1 shows an illustration of a k-space grid indicating an order in which k-space points can be acquired.

Figure 2 shows an illustration of a k-space grid indicating an order in which k-space points can be acquired.

DESCRIPTION

Fig. 1 shows a k-space grid 100 including points at which k-space is sampled. In the embodiment shown, the x-axis indicates a phase-encode direction and the y-direction indicates a slice-encode direction. It is to be understood that a read direction can be directed in direction perpendicular to both phase-encode and slice-encode directions.

In one embodiment, a first region 200 is defined in the k-space grid. In the embodiment shown the first region includes k-space points 1 through 9. An outer region of

k-space 400 includes the region of k-space within the grid 100 and outside the first region 200.

Fig. 2 shows a k-space grid 100 including points at which k-space is sampled. In the embodiment shown, the x-axis indicates a phase-encode direction and the y-direction indicates a slice-encode direction. It is to be understood that a read direction can be directed in direction perpendicular to both phase-encode and slice-encode directions.

In the embodiment shown in Fig. 2, a first region 200 is defined in the k-space grid. In the embodiment shown the first region includes k-space points 1 through 9. The embodiment shown in Fig. 2 also includes a second region 300 defined in the k-space grid. As can be seen, the second region surrounds the first region. An outer region of k-space 400' includes the region of k-space within the grid 100 and outside the first and second regions.

The slice and phase k-space points are placed in a grid spanning from the most negative to the most positive value along each axis. The distance is measured in k-space units of 1/length.

In one embodiment, acquisition data points are placed in an array that indicates the order in which k-space points are acquired.

K-space is divided into regions, for example circular regions, based on given distances. The first region can be defined by all points that are less than or equal to a given distance A. The second region can be defined by points that are outside of the distance A, but less than or equal to a next distance B. This division can continued for as many rings as desired.

The radius of the first region is based on the time desired to fill the central section. K-space points that lie within the bounds of the central ring will be acquired in the first group. K-Space points that lie within the second region will be acquired in the second group, and so on. The last group acquired lies outside the defined rings. The order of the points within each annulus is determined by the order of evaluation. For example in sequential order as shown in Fig. 1 and Fig. 2.

In one embodiment, the slice-phase k-space data points are evaluated in each pass center-out along the phase direction and serpentine along the slice direction. If the distance is less than or equal to the distance defining the central region, the data point's index is added to the k-space order array.

When all points in k-space have been examined the next ring or annulus is evaluated in the same manner. The points already used are skipped.

In another embodiment, the central region can be shuffled into random order, such that the very central point occurs in the middle half of the time to fill the central ring region.

In another embodiment, the evaluation order can take on other forms such as sequential or center-out in both directions.

In another embodiment, acquisition may be designed to depend on the timing of contrast bolus or acquisition time.

The invention has been described with reference to the preferred embodiment. Obviously, modifications and alterations will occur to others upon reading and understanding the preceding description. It is intended that the invention be construed as including all such modifications and alterations insofar as they come within the scope of the appended claims or the equivalents thereof.

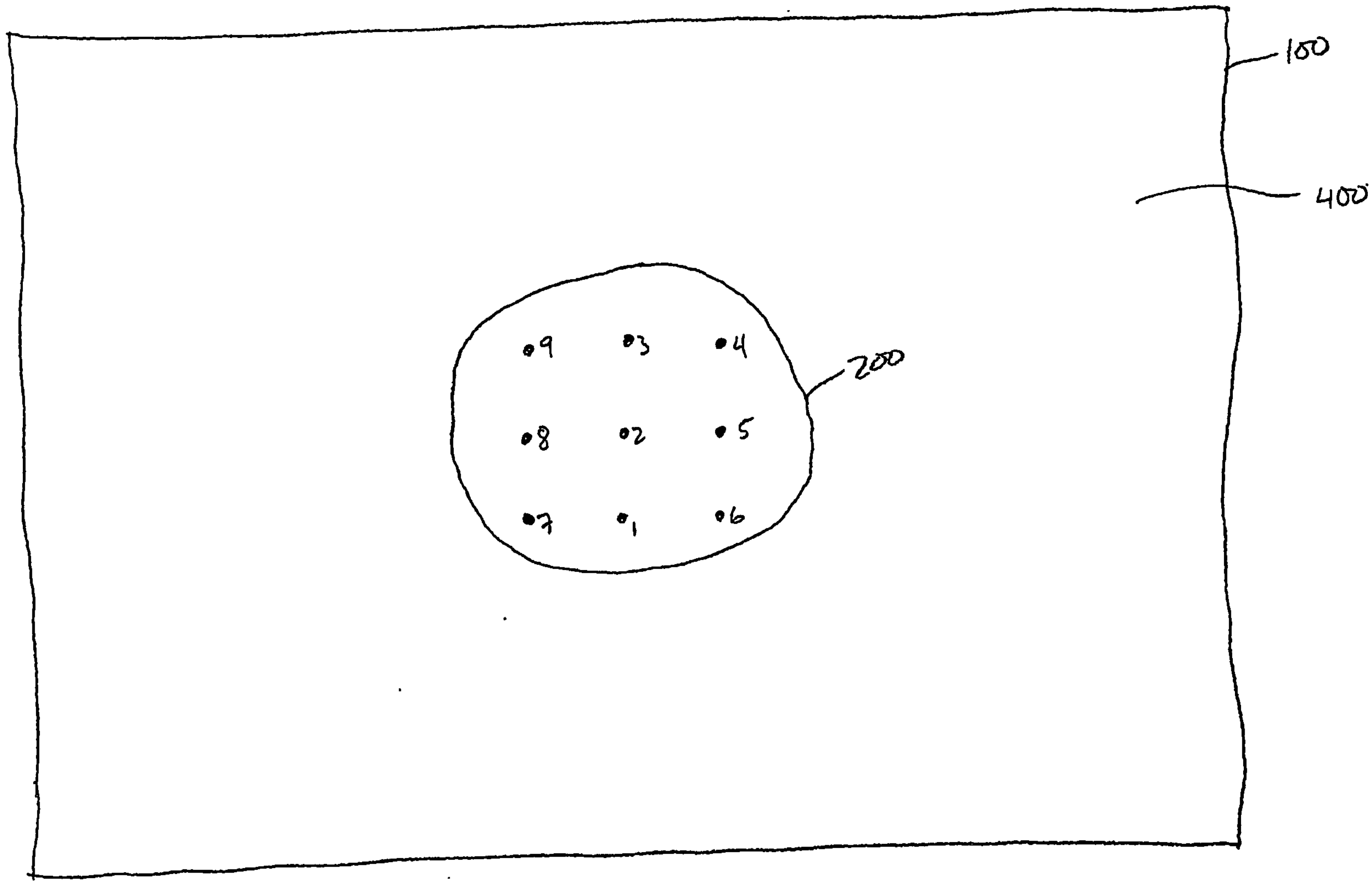

FIG. 1

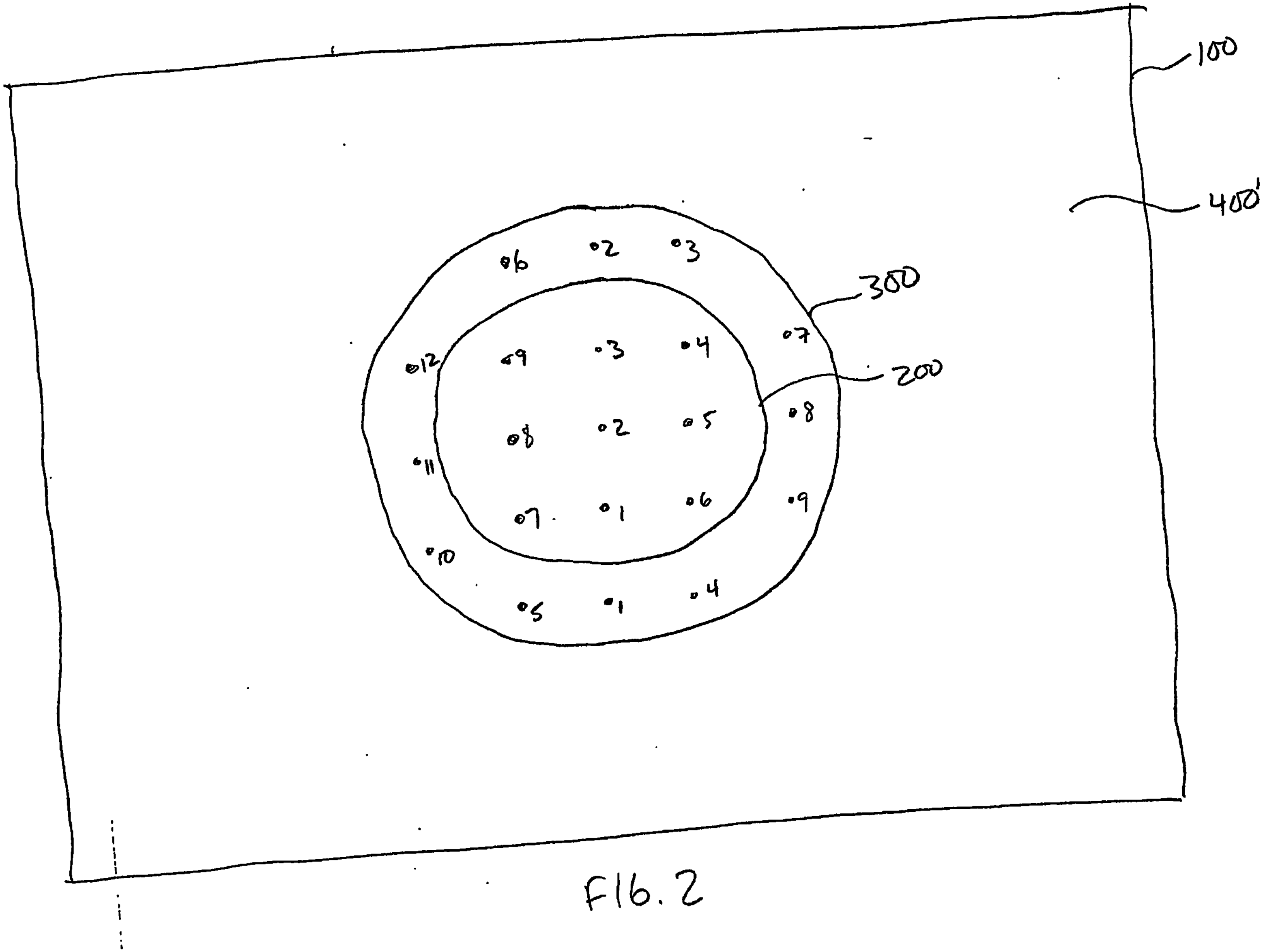

FIG. 2